Research article

Evaluate the impact of neurogenic bladder in veterans with traumatic spinal cord injury

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Objective: This observational study aimed to determine the prevalence of neurogenic bladder (NGB), and its impact (frequency of urinary tract infection [UTI], autonomic dysreflexia (AD) pressure ulcers, spasticity, and hospitalization rates) on veterans with traumatic spinal cord injury (SCI).

Background: NGB (detrusor muscle and urethral sphincter dysfunction with loss of bladder sensation to void), secondary to SCI, is commonly encountered in daily practice; however, its impact on veterans' overall health has been less well studied.

Method: We retrospectively reviewed the electronic charts of veterans with SCI enrolled in our program and regularly followed in our SCI clinic. Demographic data collected included: age, sex, race/ethnicity, and age, level, severity and cause of spinal injury. Also noted was presence of NGB, episodes of UTI, presence of pressure ulcers, AD, spasticity, and hospitalization rate. Differences between those with and without NGB were evaluated using Generalized Linear Models.

Results: Of 161 veterans with SCI, symptoms of NGB was present in 133 (83%). Presence of NGB was associated with severe spinal cord injury. Veterans with NGB had more frequent UTI and presence of pressure ulcers ($P < 0.05$). They also were more likely to need hospitalization and were at an increased risk of dying.

Conclusion: Incidence of NGB in veterans with SCI is high, is mainly associated with severe spinal cord injury, and severely impacts veterans' health by frequently causing UTIs, increasing hospitalization rate, and increases risk of death.

Keywords: Veterans, SCI, Neurogenic bladder, Urinary tract infection, Hospitalization, Observation

Introduction

Detrusor muscle and urethral sphincter dysfunction with loss of bladder sensation to void due to spinal cord injury (SCI) results in a neurogenic bladder (NGB).[1] The main types of NGB are: (a) failure to store urine from a hyperreflexic detrusor or a decrease in sphincter resistance, (b) failure to empty urine from a areflexic detrusor or an increase in sphincter resistance, or (iii) detrusor sphincter dyssynergia from lack of co-ordination between detrusor contraction and sphincter relaxation leading to high voiding pressure and incomplete emptying.[2]

Despite significant advances in managing NGB in the last 50 years and lessening the incidence of renal dysfunction,[3] NGB still continues to be a major cause of morbidity,[4,5] mortality,[6] and poor quality of life.[7,8] Morbidity is due mainly to frequent urinary tract infection (UTI) resulting from the spinal cord injury and causing impaired bladder emptying.[4,5] UTI usually increases the risk of autonomic dysreflexia (AD), spasticity, and the need for hospitalization.[5] The incidence of UTI in a retrospective study of 834 patients with SCI was found to be 20%.[9] The overall rate of UTI in patients with SCI is approximately 0.68 episodes per patient per year.[4] Prevention of urological complications after SCI is one of the primary goals of spinal cord injury program,[10] so as to reduce the incidence of recurrent UTI and the development of antibiotic resistant bacterial strains.[11] Skin maceration from both urinary incontinence and perspiration softens the protective dermis and increases the effect of pressure on the skin leading to pressure ulcers.[12] Thus measures to diminish skin exposure to wetness are paramount to reduce risk of pressure ulcers. NGB has been found to cause mortality in 10–15% of patients with SCI.[6] The NGB contributes significantly to the poor

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quality of life due to embarrassment and reluctance to socialize because of incontinence-related malodor, as well as the stress of finding the nearest restroom keeping them house-bound.[7] As a result they are at greater risk of depression than the normal population with women being at a higher risk than men.[8] Hospitalization from recurrent UTIs is frequent with 38.4% of patients with SCI in a Model Spinal Cord Injury System (MSCIS) needing to be hospitalized.[13]

We therefore decided to study the prevalence of NGB, and its impact in-terms of frequency of UTI, presence of AD, spasticity, pressure ulcers, and rate of hospitalization in veterans with SCI who are regularly followed in our SCI program on an out-patient basis. The study findings will help improve our bladder management program in these patients with SCI with NGB to prevent future recurrent UTI, re-hospitalizations, and in turn improve their quality of life.

Methods

Participants

The local Institutional Review Board for Human Subjects Research and the local Veterans Affairs Research and Development Committees' approval were obtained for the study. On retrospective chart review there were 161 veterans with SCI registered in our SCI program at the Oklahoma City VA Medical Center from 1/1/2000 through 12/31/2012, who had been routinely followed every 4 months in the out-patient clinic during this time frame. Usually veterans with SCI are enrolled in our program within a year of their injury. The average follow-up time of these patients was 10.5 ± 3.8 (SD) years. During the clinic visit patients are assessed for current medical conditions such as UTI, spasticity, AD, pneumonia, myocardial infarction, congestive heart failure, and arrhythmias. Self-care strategies for managing neurogenic bowel and bladder and pressure ulcer prevention are also reviewed. Data collected from chart review included age of injury, sex, race/ethnicity, level and severity of injury American Spinal Injury Association (ASIA) Impairment Scale (AIS) grade: A, B, C, D and E),[14] etiology (motor vehicle crash, gunshot wound, fall, diving, or other), age at onset of SCI, time since onset of the SCI, and SCI-related complications (e.g. presence of AD, depression, spasticity, pressure ulcer with or without osteomyelitis, and neurogenic bowel and bladder) on their initial evaluation and subsequent follow-up visits by a certified clinician. Survival was recorded up to 12/31/2012. Presence of UTI was defined by a urine analysis showing presence of significant bacteriuria ($\geq 10^5$ cfu/ml) in the presence of nitrites and WBC > 10/HPF, and a positive urine culture, with or without symptoms or signs such as fever (>100 degrees Fahrenheit), chills, lethargy, increasing muscle spasms, AD, malodorous and cloudy urine, lower abdominal pain/tenderness provided no other potential etiology for these non-specific complains were identified. Antibiotics were prescribed based on urine culture and sensitivity findings. Asymptomatic bacteruria was not treated.

NGB was initially defined on the clinical complains of altered bladder function after injury resulting in incomplete (retention) or frequent (frequency, urge incontinence, or incontinence) bladder emptying, in the absence of any pelvic pathology especially prostate related issues (as our patients are mainly men). This was followed by urodynamic study to characterize the functional classification of NGB to plan their treatment.

Prevalence was defined as a cross-sectional count of the number of cases (e.g. persons with SCI with NGB) that occurred in a particular population within a specific period of time.[15] In this study, prevalence was based on the number of persons who visited the VAMC SCI outpatient clinic for the period January 2000 to December 2012 inclusive. Veterans Health Administration directive stipulates that veterans with SCI and NGB should have a bladder management program based on the specific bladder dysfunction found on the initial urodynamic study once clinically stable after their initial injury. These veterans should on each follow-up visit be tested for blood urea nitrogen (BUN), creatinine, glomerular filtration rate (GFR) and urinary analysis. They should have a yearly renal ultrasound to evaluate renal structure, a radionuclide renal scan to evaluate both structure and function by measuring GFR, a urology consult for cystoscopy to evaluate bladder structure and urodynamic study to evaluate bladder function when needed.

Statistical analysis

Group descriptive statistics were expressed as mean ± standard deviation and grouped frequencies. For outcomes that were not dependent on length of follow-up (e.g. NGB, AIS grade) differences between groups were assessed using the Generalized Linear Model framework. In the simplest case of two group comparisons without covariates this is equivalent to using *t*-tests for continuous variables and χ^2 for categorical data, but allows generalization to include covariates in the model. Covariates considered were age at the time of injury, severity of injury (AIS grade), and duration since SCI. For outcomes that were dependent on length of follow-up (e.g. number of UTIs, occurrence of depression) differences between groups were assessed using a weighted Generalized Linear Model framework

with weights proportional to the length of follow-up. Difference in mortality rates between groups was assessed using a Cox-proportional hazards model. Data analyses were conducted using IBM SPSS Statistics (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY). Results corresponding to P-values lower than 5% are described as significant and reported.

Results

Table 1 presents the baseline characteristics of our study sample ($N = 161$). The mean age was 59.5 ± 13.6 years (range 25–90 years), male: female ratio was 157:4, 81% were non-Hispanic white, age at onset of injury was 38.8 ± 15.8 years (range 18–82 years), and duration since SCI insult 20.6 ± 16.6 years (range 1–68 years). The most common cause of injury in 47% was motor vehicle/cycle accident followed by falls in 29% cases. Just over half (55%) had a cervical spinal level of injury. Just over half had complete motor spinal cord injury (52% AIS A or B). Symptoms of NGB such as urinary incontinence were present in 133 of the 161 patients with SCI giving a prevalence of 83% over the 13-year study period. Patients with NGB were more likely to have complete motor spinal cord injury (60% AIS A or B) compared to patients with non-NGB, who were more likely to have incomplete motor spinal cord injury (82.6% AIS D or E) ($P < 0.001$).

Patients with NGB symptoms compared to patients with no symptoms had more frequent episodes of UTI (1.4 ± 2.7 vs. 0.2 ± 0.7, $P < 0.001$), pressure ulcers (36% vs. 0%, $P < 0.001$) and AD (23% vs. 0%,

Table 1 Comparison of the study variables between patient groups with spinal cord injury (SCI) based on presence or absence of neurogenic bladder (Mean ± Standard Deviation, or *n* (%), as appropriate)

Grouping Variables	Total ($n = 161$)	Neurogenic Bladder ($n = 133$)	Non-Neurogenic Bladder ($n = 23$)	P-value
Age at present (years)	59.5 ± 13.6	59.4 ± 13.1	60.3 ± 16.9	0.76[t]
Sex (Male: Female)	157:4	131:2	21:2	0.12[f]
Race/Ethnicity (White/Black/Native Indians/ Hispanics/Unknown)	130/22/4/4/1	106/20/3/4	20/2/1/0	0.92[c]
Age at onset of SCI (years)	38.8 ± 15.8	37.7 ± 14.7	42.6 ± 20.4	0.19[t]
Duration since SCI (years)	20.6 ± 16.6	21.4 ± 16.1	17.1 ± 20.3	0.27[t]
Spinal Injury level				
Cervical	88	67 (50)	18 (78)	0.15[c]
Thoracic	52	48 (36)	3 (13)	
Lumbosacral	21	18 (14)	2 (9)	
Spinal Injury severity (AIS grade):				
A	58	57 (43)	0 (0)	0.000[c]
B	25	23 (17)	1 (4)	
C	31	26 (20)	3 (13)	
D	37	22 (17)	14 (61)	
E	10	5 (4)	5 (23)	
Etiology of SCI				
Motor Vehicle Accident	62	52 (39)	7 (30)	0.13[c]
Motor Cycle Accident	13	10 (8)	2 (9)	
Gunshot	19	19 (14)	0 (0)	
Fall	46	36 (27)	10 (43)	
Diving	5	5 (4)	0 (0)	
Others	15	11 (8)	3 (13)	
Risk Factors				
Hypertension	74	59 (44)	12 52)	0.75[f]
Diabetes Mellitus	36	29 (22)	5 (22)	0.93[f]
Hyperlipidaemia	67	53 (40)	12 (52)	0.37[f]
Body Mass Index (BMI)	26.8 ± 7.7	26.5 ± 7.7	27.7 ± 6.8	0.47[t]
Current Smoker	60	49 (37)	9 (39)	0.99[f]
Depression	70	57 (43)	10 (43)	0.67[w]
Pressure ulcers	50	48 (36)	0 (0)	0.001[w]
Autonomic dysreflexia	32	30 (23)	0 (0)	0.0079[w]
Urinary tract infection	1.2 ± 2.5	1.4 ± 2.7	0.2 ± 0.7	0.037[w]
Spasticity	91	79 (62)	12 (52)	0.30[w]
Dead	67	60 (45)	7 (30)	0.35[x]

[t] = Student's *t*-test.
[c] = χ^2 test.
[f] = Fisher's exact test.
[w] = Weighted general linear model.
[x] = Cox proportional hazards model.
AIS = ASIA Impairment Severity grade.

P = 0.007). Spasticity was more frequent in patients with NGB symptoms but did not reach statistical significance (62% vs. 52%, P = 0.39). Of the 30 SCI patients with NGB symptoms who had AD, 15 patients (50%) had both UTI and spasticity, 11 patients had only spasticity (37%), and 4 patients had only UTI (13%). Likewise more patients with NGB symptoms died compared to patients with non-NGB (50% vs. 30%); however, this difference did not reach statistical significance (P = 0.089). Of the patients who died the cause of death as per their death certificate was: respiratory mainly pneumonia ($n = 17$, 28%), septicemia (14, 23%), cancer mainly lung (8, 13%), cardiac mainly myocardial infarction (8, 13%), strokes (3, 5%), and in 9 patients who died at home the cause of death could not be ascertained (15%).

In this study UTI was present in 62 of the 161 patients with SCI (39%). The overall rate of UTI in patients with SCI was 0.06 episodes per patient year. Patients with UTI had more frequent urological lesions such as renal atrophy (18%) and hydronephrosis (12%) compared to those without UTI (3% and 3%, respectively, P < 0.05). More patients with UTI were hospitalized (53 of 62 (86%), 3.6 ± 4.9 hospital visits for UTI per patient) compared to non-UTI group (0.2 ± 0.5 hospital visits for UTI per patient) (P < 0.001). Re-hospitalization was due mainly to complaints of fever, chills, AD and increasing muscle spasms as veterans were aware that presence of these complains indicated to them the presence of a UTI from their prior experiences.

Discussion

Given that the consequences of NGB are preventable,[5] Veterans Health Administration Directive 1176 stipulates that all eligible veterans with Spinal Cord Injury and Disorder (SCI&D) be provided with a full range of care to promote and maintain health, independence, and quality of life so they can be productive individuals.

In this retrospective longitudinal study, which is the first to look at the prevalence of NGB in veterans with SCI, the prevalence of NGB was 83% over a 13-year period. The presence of NGB was influenced mainly by the severity of the spinal cord injury as measured by AIS grading and not the spinal level of the lesion. Patients with NGB were found to have more frequent episodes of UTI, AD and pressure ulcers. The presence of more frequent AD and pressure ulcers in this study was solely due to the severity of SCI and not by the presence of NGB. Rabadi and Vincent in their study also showed that patients with severe spinal injury (AIS A, B, or C) were more likely to have pressure ulcers.[16]

We had a higher incidence of UTI (39%) in our study compared to 20% in another study.[10] This was due mainly to the higher level (84% cervical and thoracic) and more severe (52% AIS A and B) cord injuries in our patient population. The overall rate of UTI in patients with SCI was 0.06 episodes per patient year. This compares to the 0.68 episodes per patient per year in the prospective study of Esclarin *et al.*[4] which had a restrictive definition of UTI (did not include symptoms), lesser number of patients with SCI enrolled ($n = 128$) and followed for a shorter duration (38 months). However, in the current study, if only those with up to three years (36 months) of time since injury, the overall rate of UTI was 0.46 episodes per patient year. In the current study the risk factors for UTI were cervical level of injury, severity of injury (AIS A and B), and chronic in-dwelling catheterization. Esclarian *et al.* had similar findings in their study.[4] Our re-hospitalization rate in patients with SCI with UTI was 86%. Patients with UTI who needed frequent re-hospitalization due to complaints of fever, chills, AD and increasing muscle spasms had other urological lesions present such as renal atrophy and hydronephrosis on renal scan. Cardenass *et al.*[5] in their study of 8668 patients with SCI in the Modular Spinal Cord Injury Services over a 20-year time period had a re-hospitalization rate of 28% to 37%. In their study patients with severe SCI (categories AIS grade A, B, or C) needed frequent re-hospitalization, and though this was due mainly to UTI, it also included other causes such as pressure ulcers, pneumonia, and diseases of the musculoskeletal system.

There are several limitations of this study: First, this study was limited to a veteran population predominantly comprised of white men, so it may not be generalizable to the general population. Second, the small sample size may have precluded detection of clinically relevant differences between groups; for example, an increased occurrence of spasticity. Third, this was a single center study. Fourth, of the 161 patients with SCI, 40 patients had UDS undertaken at our facility. The rest had UDS undertaken at other VA facilities prior to their transfer of care at our facility. We continued with their recommendations but did not receive the UDS report from them. This limits one's ability to classify the types of NGB as one would hope for. Finally, the inherent bias associated with retrospective studies should be considered. However; the strength of this study lies in the completeness of the data captured by the standardized SCI registry over a 13-year period with no patient lost to follow-up.

Conclusion

This study shows (1) the prevalence of NGB in veterans with SCI is high (83%), (2) that NGB patients typically had a more severe grade of spinal injury, and (3) an increased presence of UTI, AD, and pressure ulcers with required frequent hospitalization and negatively affect their quality of life, limit their ability to live independently, and is associated with an increased death rate.

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References

1 Rackley R, Kim ED. Neurogenic Bladder. Available from http://emedicine.medscape.com/article/453539-overview (Accessed September 2012).
2 Wein AJ. Classification of neurogenic voiding dysfunction. J Urol 1981;125(5):605–9.
3 DeVivo MJ, Krause JS, Lammertse DP. Recent trends in mortality and causes of death among persons with spinal cord injury. Arch Phys Med Rehabil 1999;80(11):1411–9.
4 Esclarín De Ruz A, García Leoni E, Herruzo Cabrera R. Epidemiology and risk factors for urinary tract infection in patients with spinal cord injury. J Urol 2000;164(4):1285–9.
5 Cardenas DD, Hoffman JM, Kirshblum S, McKinley W. Etiology and incidence of rehospitalization after traumatic spinal cord injury: a multicenter analysis. Arch Phys Med Rehabil 2004; 85(11):1757–63.
6 Soden RJ, Walsh J, Middleton JW, Craven ML, Rutkowski SB, Yeo JD. Causes of death after spinal cord injury. Spinal Cord 2000;38(10):604–10.
7 Ku JH. The management of neurogenic bladder and quality of life in spinal cord injury. BJU Int 2006;98(4):739–45.
8 Oh SJ, Shin HI, Paik NJ, Yoo T, Ku JH. Depressive symptoms of patients using clean intermittent catheterization for neurogenic bladder secondary to spinal cord injury. Spinal Cord 2006; 44(12):757–62.
9 Whiteneck GG, Charlifue SW, Frankel HL, Fraser MH, Gardner BP, Gerhart KA, *et al.* Mortality, morbidity, and psychosocial outcomes of persons spinal cord injured more than 20 years ago. Paraplegia 1992;30(9):617–30.
10 Smith JM. Indwelling catheter management: from habit-based to evidence-based practice. Ostomy Wound Manage 2003;49(12): 34–45.
11 Hinkel A, Finke W, Bötel U, Gatermann SG, Pannek J. Increasing resistance against antibiotics in bacteria isolated from the lower urinary tract of an outpatient population of spinal cord injury patients. Urol Int 2004;73(2):143–8.
12 Mayrovitz HN, Sims N. Biophysical effects of water and synthetic urine on skin. Adv Skin Wound Care 2001;14(6):302–8.
13 Eastwood EA, Hagglund KJ, Ragnarsson KT, Gordon WA, Marino RJ. Medical rehabilitation length of stay and outcomes for persons with traumatic spinal cord injury—1990–1997. Arch Phys Med Rehabil 1999;80(11):1457–63.
14 Kirshblum SC, Burns SP, Biering-Sørensen F, Donovan W, Graves DE, Jha A, *et al.* International standards for neurological classification of spinal cord injury (Revised 2011). J Spinal Cord Med 2011;34(6):535–46.
15 Sackett DL, Straus SE, Richardson WS, Rosenberg WMC, Haynes RB. Evidence-based medicine: how to practice and teach EBM, 2nd ed. London, UK: Churchill Livingstone; 2000.
16 Rabadi MH, Vincent AS. Do vascular risk factors contribute to the prevalence of pressure ulcer in veterans with spinal cord injury? J Spinal Cord Med 2011;34(1):46–51.